DOCUMENT RESUME

ED 334 481 CG 023 496

AUTHOR Niskanen, Vesa A.
TITLE Describing Personality Utilizing the Theory of Fuzzy Systems. Research Bulletin 76.
INSTITUTION Helsinki Univ. (Finland). Dept. of Education.
REPORT NO ISBN-951-45-5579-1; ISSN-0359-5749
PUB DATE 90
NOTE 24p.
PUB TYPE Viewpoints (Opinion/Position Papers, Essays, etc.) (120)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Concept Formation; Foreign Countries; *Personality
IDENTIFIERS Finland; *Fuzzy Set Theory

ABSTRACT

This paper principally examines personality from a philosophical standpoint. First, problems related to the definition of this subject-matter are considered. Descriptive definitions and stipulative definitions are discussed. Second, a description of personality based on the Theory of Fuzzy Systems (TFS) and computers is suggested. The basic idea of this theory is that, in addition to the conventional sets and relations, vague sets and relations may also be used. It is noted that when fuzzy linguistic models are used, problems related to both the mere degrees of membership and conventional methods are eliminated because linguistic values may be regarded as elastic restrictions, thus better describing the nature of vague concepts. A concrete example of concept formation is provided. These conclusions are summarized: (1) the definition of personality is problematic using conventional methods because it is vague, complex, and complicated by nature; (2) the TFS, on the other hand, seems to be an intelligible approach because it deals with vague and complex entities elegantly; and (3) owing to the employment of TFS, computerized procedures may also be utilized conveniently in the concept formation of personality. (LLL)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED334481

Department of Education

University of Helsinki

BEST COPY AVAILABLE

RESEARCH BULLETIN 76

Vesa A Niskanen

DESCRIBING PERSONALITY UTILIZING THE THEORY OF FUZZY SYSTEMS

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

E. Niskanen

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

C6023496

Department of Education, University of Helsinki
Head: Anna-Liisa Leino, Professor of Education (Swedish)
Bulevardi 18, SF-00120 Helsinki, Finland

RESEARCH BULLETIN 76

Vesa A Niskanen

DESCRIBING PERSONALITY UTILIZING THE THEORY OF FUZZY SYSTEMS

Helsinki 1990

ISBN 951-45-5579-1
ISSN 0359-5749
Helsinki 1990
Yliopistopaino

University of Helsinki
Department of Education

Research Bulletin No. 76, 1990

Vesa A Niskanen
Describing personality utilizing the theory of fuzzy systems. 16 pp.

ABSTRACT

This study examines the term "personality". First, the philosophical background is outlined. Second, a description of "personality" based on the Theory of Fuzzy Systems and computerization is suggested. Finally, a concrete example of concept formation is provided.

Keywords: personality, concept formation, fuzzy systems

ISBN 951-45-5579-1
ISSN 0359-5749

Available from: Department of Education
University of Helsinki
Bulevardi 18
SF-00120 Helsinki, Finland
Tel.int: +358 0 1911
Telefax: +358 0 1918073

PREFACE

This study is a part of the research project on examination of *personality* conducted by Professor Erkki A. Niskanen. The aims of this study, which were established by the project, are (i) to consider *personality* from the philosophical standpoint, especially from the viewpoint of concept formation, and (ii) to apply the *Theory of Fuzzy Systems* to this subject-matter.

I wish to express my gratitude to Professor Erkki A. Niskanen for his valuable ideas and comments. I am also greatful for the inclusion of this study in the Research Bulletin series of Department of Education.

Helsinki, October 1990

Vesa A Niskanen

CONTENTS

1. Philosophical background 1

2. The fuzzification approach 7

3. Summary 14

NOTES 15

REFERENCES 16

1. Philosophical background

In this study "personality" is examined principally from the philosophical standpoint. First, the problems related to the definition of this subject-matter will be considered. Second, an approach describing personality from the standpoint of the *Theory of Fuzzy Systems* will be presented. Finally, a concrete example of concept formation is provided. This inquiry stems from the ideas suggested in [10], [14], [15] and [11].

Vague and *complex* terms are characteristic of the Behavioural Sciences. Vagueness may be ontological, epistemological, or linguistic in nature (cf. [11]):

(i) The ontological approach considers whether vague entities actually exist. For example, is *personality* a vague entity?

(ii) In epistemological inquiry vagueness is related to human mental processes and it is assumed to be caused by people's inability to conceptualize certain entities as being exact in nature. For example, *personality* may be an exact entity *in re*, but human beings are incapable of conceptualizing it in this manner.

(iii) The linguistic approach assumes that vagueness is assigned to linguistic expressions. For example, "personality" may thus be a syntactically, semantically, or pragmatically vague term. In the sequel, the inquiry will be focused on the linguistic view, particularly on extensional semantics because this approach is the most usual one in the philosophy of science. Bearing in mind this approach, in the case of a *vague term* it is problematic whether certain objects of the actual world are members of its extension. As regards the term "personality", the basic problem will thus be the specification of the set of persons[1].

"Vagueness" and "uncertainty" have sometimes been confused. However, a clear distinction may be drawn: Uncertainty is the object of epistemological inquiry, and it presupposes that the factors concerning a given phenomenon are not sufficiently known, or that the output of a given process is unknown in advance. Let us consider, for example, the statements

(i) "John is probably 30 years old",
(ii) "John is young" and
(iii) "John is probably young".

Then, the first statement is related to uncertainty because this expression means that John's age is not definitely known. In the second case we know John's age but, the specification of

the set of young persons is problematic because of the linguistic vagueness of the term "young". The third statement comprises both a vague and an uncertain constituent.

As regards complexity, if the semantic extensional approach is maintained, it is assumed that the meaning of a complex term is composed of the meanings of other terms, these known as the *meaning components*. Meaning components may form various structures such as hierarchies. Hence, "vagueness", for example, is a complex term. Defining semantic extensional complexity in this manner, "complexity" may be distinguished from "complicacy": In the former case the examination is focused on the number of meaning components and the variety of interdependence among the components (cf. [6]). Ambiguous terms (e.g. "theory") are clear examples in this context. In the latter case the basic problem is to understand the meaning of a given term completely, and this procedure is not necessarily dependent on complexity. For example, the meaning of the term "a four-dimensional cube" may be complicated, but it is obviously not complex. Hence, three types of terms are possible in this respect: Complex terms, complicated terms, and both complex and complicated terms.

"Personality" seems to be a vague, complex and complicated term. This is due to the following facts:

(i) The extension of this term (viz. the set of persons) contains borderline cases, i.e., it is problematic to specify sharp boundaries for this set. For example, is a mentally disabled human being a person? Hence, vagueness is involved in the term "personality".

(ii) It consists of several meaning components such as "rationality" and "a sense of humour". Thus, "personality" is a complex term. Some of the proposed meaning components, however, are controversial, for example, "intentionality".

(iii) It is obviously problematic to understand the nature of personality completely. This is a well-known fact in the Behavioural Sciences, and "personality" is thus a complicated term.

As a thorough examination of personality from the standpoint of the Behavioural Sciences has been performed elsewhere ([10]), a purely philosophical approach will be provided below. In addition, the object of study will be focused on the problems of vagueness and complexity because: (i) In these contexts both new and improved methods have been recently suggested (cf. below). (ii) The examination of complicacy presupposes considerations characteristic of the Behavioural Sciences rather than methodology. Hence, problems related to the definition of vague and complex terms will first be considered.

Definitions play an essential role in scientific concept formation because then the meanings of the terms may usually be presented explicitly. Psychological aspects usually presuppose that definitions should describe the meanings of new terms, replace long expressions by shorter ones, and resolve the meanings of complex terms on the basis of their constituents (cf. [3]). From the methodological standpoint it is usually presupposed that satisfactory definitions should be clear, applicable, theoretically fruitful, and powerful with respect to systematization ([5]). Hence, we must bear in mind these facts, when attempting to describe *personality*.

According to the traditional view on definition, which is based on Aristotle's considerations, the *essence* of a thing should be specified. The essence of a thing comprises a set of attributes which are necessary and sufficient conditions for any concrete thing to be a thing of a given type. The essence has two aspects: The *genus* is that which is predicable essentially from other types of things as well, and the *differentia* is that part of the essence which distinguishes the *species*, i.e., things of one type, from other species. For example, if we define the term "man" as follows:

"Man" $=_{df}$ "Rational animal"

then, according to Aristotle, the genus is "animal" and the differentia is "rational"[2]. Attributes which do not indicate the essence of a thing, but yet follow necessarily from the definition, Aristotle called *properties*. For example, in the case of "man" one property of man is to be capable of learning grammar. Correspondingly, the Aristotelian view presupposes that in the case of "personality" the respective essence should be specified.

As the purpose of Aristotle's definition is to describe the essence of a thing, it presupposes the employment of *factual statements*, i.e., statements expressing conformities to scientific laws, in its definiens. In addition, if the definiendum is correctly described in this manner, then the definition is true. Definitions of this type have traditionally been known as *real definitions*.

According to the modern view, definitions may be classified into two principal groups ([5]):

(i) *Descriptive definitions* state or describe the accepted meaning, or meanings, of a term already in use.

(ii) *Stipulative definitions* assign, by stipulation, a special meaning, such as a newly coined verbal or symbolic expression, or a term used in a specific technical sense to a given term.

BEST COPY AVAILABLE

The descriptive definitions are more or less precise, and they may be true or false. In addition, these definitions may be either *analytic* or *non-analytic* by nature[3]. In the former case the definienda are described by specifying their identical intensions: For example, in the case

"Father" $=_{df}$ "Male parent",

the meaning of the term "father" is described with the aid of antecedently understood meanings of the terms "male" and "parent". Correspondingly, the analytic description of "personality" should only be based on the antecedently understood meanings of terms, this approach, however, seems to raise problems in practice because of the synthetic nature of "personality".

In the non-analytic case, on the other hand, the descriptions are based on the specifications of identical extensions: For example, the definition

"Man" $=_{df}$ "Rational animal"

is true if the set of men is identical with the set of rational animals. Hence, in the context of "personality" an expression whose extension is identical with the set of persons should be specified. In the light of the modern classification the traditional real definition corresponds best with the non-analytic case.

As regards stipulative definitions, i.e., *nominal definitions* and *explications*, only the latter type seems relevant when vague and complex terms are examined. If the explication is used, then a precise and technical meaning is assigned to a term which is possibly understood vaguely or ambiguously in common usage ([2]). For example, as a result of explication the term "fish" (viz. the *explicandum*), which may be regarded as a vague term in common usage, has been replaced by the term "pisces" (viz. the *explicatum*) in the scientific community. In practice, this procedure means that the extension of the explicatum includes, by the stipulation of the scientific community, at least the unproblematic cases. Hence, if "personality" is explicated, the set of persons has to be precisely and unambiguously stipulated. As definitions of this type are based on stipulations or conventions, they apparently may not be qualified as true or false.

The application area of the real definition is fairly resticted because it describes the meaning of a monadic predicate as a conjunction of two monadic predicates. Hence, it is inappropriate in both dyadic and polyadic cases. In addition, complex terms raise problems: For example, the definition of "parent" presupposes the employment of disjunction (viz. "Parent" $=_{df}$ "Father

or mother"), and this strategy is not in accordance with the *genus-differentia* -principle characteristic of a real definition. On the other hand, this definition seems satisfactory if it is applied correctly; for example, if informative aspects of the definiens are emphasized ([5]).

Real definitions and their modern counterparts, non-analytic definitions, also seem inappropriate in the case of vague terms because they presuppose that descriptions of meanings have to be performed *explicitly*. This means that, *inter alia*, context-free and precise terms should be used in the definiens (cf. [8]). Because of these strict conditions, in the praxis of research, especially in the Behavioural Sciences, alternative approaches have been used in order to maintain the informative and interpretative nature of definitions (cf. [5]).

Explication is also problematic in the context of vague terms because it presupposes that the extension of the definiendum should have sharp boundaries. For example, a person is defined as being young if he/she is n years old at most, otherwise he/she is non-young. Hence, the borderline cases are usually ignored, this leading to artificial cutoffs of extensions, a situation which is obviously unintelligible (cf. [11]).

Wittgenstein [13] attempted to solve the problems related to vague and complex terms formulating the principle of *family resemblance*. According to this strategy, the description of the essence of a thing is impossible in the case of vague and complex terms and therefore the definiens should include terms which are *characteristic* but not *necessary* of the definiendum. For example, the term "man" should consist of generally accepted meaning components such as "rational", "two-legged" and "having a sense of humour". However, unlike Aristotle, Wittgenstein suggested that a being may be regarded as man if *most* of these components may be assigned to it. Hence, if a being X is one-legged but fulfils the rest of the given conditions, X may be regarded as man. In addition, he emphasized the role of exemplification when terms of this type are described. Putnam [12] calls the meaning components of this type the *cluster terms*. In the context of "personality" the family resemblance view presupposes that this term is a cluster term and hence certain common and/or universal features of persons do not necessarily exist.

The family resemblance approach seems to solve the problems related to the definition of vague and complex terms only partially in the praxis of research. This is due to the following reasons: (i) The application of the principle "most of the cluster terms" raises difficulties because of its vague nature. (ii) The cluster terms should usually be weighted, this procedure being often problematic. (iii) This approach is based on bivalent logic; hence, cluster terms are either assigned or not assigned to a given definiendum, and partial memberships are thus impossible. In general, this approach, however, seems to provide an intelligible basis for the definition of vague and complex terms if certain modifications are made (see below).

As the specification of satisfactory definitions may raise problems, certain rules have traditionally been suggested for this procedure. The following are the most typical ones (cf. [3], p. 238):

(i) A definition has to describe the essence of a given thing.

(ii) A definition is not allowed to be circular.

(iii) A definition must not be stated in negative terms when it can be stated in positive terms.

(iv) A definition should not be expressed in obscure or figurative language.

Two of these rules, however, are unjustified in the light of the modern conduct of inquiry ([3], [5]): Problems related to the essence of a thing (rule (i)) have already been considered in the context of real definitions. Rule (iii) is problematic in the context of explicit defifinitions because these may include arbitrary conventional connectives such as negations. In addition, certain terms may be defined elegantly using negative terms, for example, "Orphan" $=_{df}$ "A child who has not parents".

Rule (ii) presupposes that some terms always have to be selected for the *primitive terms*, i.e., terms which already have a meaning in common usage or in the scientific community and which provide a basis for defining all the other terms. A clear example of this procedure is the *axiomatic formulation*, such as the modern axiomatizations of Euclidean geometry, in which the definitions of the terms are based on sets of explicitly specified primitive terms.

When attempts are being made to define vague and complex terms, the basic problem is whether we manipulate these terms or the logic behind them. The former approach, which is characteristic of explication and the principle of family resemblance, seems inappropiate in the light of the foregoing considerations. The latter view, on the other hand, which usually presupposes the employment of many-valued logic, seems justifiable if a correct logical apparatus is selected. Below, the latter view is adopted and the *Theory of Fuzzy Systems* (TFS) has been utilized because:

(i) The TFS stems from many-valued logics. Hence, sharp boundaries of extensions are not necessary, this excluding artificial cutoffs.

(ii) This approach either resolves or avoids certain paradoxes typical of bivalent or conventional many-valued logics in the context of vague terms (cf. [7], [11]).

(iii) Linguistic values and relations, which are characteristic of the Behavioural Sciences, may be used elegantly. In addition, these may be computerized conveniently, and thus permitting utilization of automated procedures.

(iv) Several scientific theories and models are based on laws and empirical results which are expressed using vague and complex statements. On the other hand, the theories *per se* are often formulated using precise (e.g. mathematical) expressions. Because of this discrepancy, it is often possible that theories and models are actually idealizations describing counterfactual conditions. For example, because of precision overstraining and over-interpreting of the constituents a theory may occur ([9], [11]). This problem may be eliminated if the TFS is utilized (cf. item (iii)).

(v) The TFS has shown promising and applicable results in various branches of science (e.g. taxonomy, decision theory, control theory, and artificial intelligence; see [1]) as well as in ordinary life (e.g. home electronics).

2. The fuzzification approach

As was mentioned above, a method based on the TFS will be applied below when vague and complex terms are considered. At first, some basic concepts of this theory will be sketched. The TFS was originally formulated by Zadeh (see, e.g. [6]), and the basic idea of this theory is that, in addition to the conventional sets and relations, vague sets and relations may also be used. These vague entities have been referred to as *fuzzy* sets and relations. For example, persons aged 20 years have full membership, persons aged 35 partial membership and persons aged 50 non-membership in the fuzzy set of young persons. More formally, fuzzy sets may be characterized by a *membership function*

$$m:E\rightarrow[0,1]$$

in which E is a so-called *reference set* and [0,1] is the closed interval from 0 to 1. Unity and zero are assigned to the full membership and non-membership, respectively. For example, in the case of young persons E is the set of ages and the following degrees of membership may be obtained:

$$m(20)=1;\ m(35)=0.6;\ m(50)=0.$$

As regards the problem of complexity, Zadeh has stated as follows ([14], p. 204):

> "... as the complexity of system increases, our ability to make precise and yet significant statements about its behaviour diminishes until a threshold is reached beyond which complexity, precision and significance no longer coexist. The essence of the linguistic approach, then, is that it sacrifies precision to gain significance, thereby making it possible to analyze in an approximate manner those humanistic as well as mechanistic systems which are too complex for the application of classical techniques."

As conventional sets may always be replaced by fuzzy sets, any system may be fuzzified, this making it more versatile and applicable. Below, this idea will be utilized in the concept analysis of "personality".

It seems plausible that in the case of the term "personality" the respective extension may be regarded as a fuzzy set because this term is vague. Hence, some beings have only partial memberships in this set. In addition, due to the complexity of this term, these degrees of membership are based on the degrees of membership of the respective meaning components.

These meaning components may form a structure such as a hierarchy of the type

PERSONALITY

LEVEL 1:	$<COMPONENT_{11}>$	...	$<COMPONENT_{1M}>$
LEVEL 2:	$<COMPONENT_{21}>$	...	$<COMPONENT_{2N}>$
	.		
	.		
	.		
LEVEL Q:	$<COMPONENT_{Q1}>$	...	$<COMPONENT_{QP}>$
E:	$<BEING_1>$	...	$<BEING_K>$

For example, "personality" may, *inter alia*, consist of the following components:

		"Personality"	
Level 1:	"Rationality"	"Decency"	"A sense of humour"
Level 2:	"Consistency"	"Politeness"	"Extroversy"

The respective extensions are fuzzy sets and the goal is to assign a degree of membership to being *X* with respect to the fuzzy set BEING A PERSON. Hence, this procedure is analogous to *multi-criteria decision making*, i.e., the ultimate assessment (viz. describing personality) is based on assessments given with respect to certain criteria (viz. the meaning components).

As a concrete example, the fuzzified approach is compared with the conventional one. Suppose that being *x* seems to be consistent (but not very consistent), more or less inpolite, and more or less extrovert. Then, if the degrees of membership are used at the input stage, the foregoing linguistic nuances may be taken into consideration. The conventional approach, on the other hand, is based on either-or -type decisions, and *x* is thus, because of more or less overstrained roundings, regarded as clearly consistent, inpolite and extrovert. The following types of weighted membership functions, for example, may be used in the case of being *x* (operations based on weighted arithmetic means):

$m_{\text{RATIONAL}}(x) = 0.9\, m_{\text{CONSISTENT}}(x)+0.05\, m_{\text{POLITE}}(x)+0.05\, m_{\text{EXTROVERT}}(x)$
$m_{\text{DECENT}}(x) = 0.05\, m_{\text{CONSISTENT}}(x)+0.9\, m_{\text{POLITE}}(x)+0.05\, m_{\text{EXTROVERT}}(x)$
$m_{\text{HAVING A SENSE OF HUMOUR}}(x) = 0.05\, m_{\text{CONSISTENT}}(x)+0.05\, m_{\text{POLITE}}(x)+0.9\, m_{\text{EXTROVERT}}(x)$

$m_{\text{BEING A PERSON}}(x) = 0.5\, m_{\text{RATIONAL}}(x)+0.3\, m_{\text{DECENT}}(x)+0.2\, m_{\text{SENSE OF HUMOUR}}(x)$

Suppose that the following degrees of membership, which are based on the foregoing linguistic assessments, are assigned as input values:

	Degree of membership	
Basic set	**Fuzzy**	**Conventional**
Consistency:	0.9	1
Politeness:	0.35	0
Extroversy:	0.65	1

Then, according to these values, the following decision tables may be constructed (cf. the weighted functions above):

		Degree of membership	
	Weight	**Fuzzy**	**Conventional**
Criterion			
Consistency:	0.9	0.81	0.9
Politeness: 0.05	0.02	0	
Extroversy:	0.05	0.03	0.05
Decision / $m_{RATIONAL}(x)$		0.86	1

		Degree of membership	
	Weight	**Fuzzy**	**Conventional**
Criterion			
Consistency:	0.05	0.05	0.05
Politeness:	0.9	0.32	0
Extroversy:	0.05	0.03	0.05
Decision / $m_{DECENT}(x)$		0.40	0

		Degree of membership	
	Weight	**Fuzzy**	**Conventional**
Criterion			
Consistency:	0.05	0.05	0.05
Politeness:	0.05	0.02	0
Extroversy:	0.9	0.59	0.9
Decision / $m_{SOPHUMOUR}(x)$		0.66	1

		Degree of membership	
	Weight	Fuzzy	Conventional
Criterion			
Rationality:	0.5	0.43	0.5
Decency:	0.3	0.12	0
Sense of Humour:	0.2	0.13	0.2
Final decision / $m_{\text{BEING A PERSON}}(x)$		0.68	1

Hence, according to the fuzzified approach, being x is a member of the set of persons with the degree 0.68 which may be interpreted that x is more or less clearly a person. The conventional method, on the other hand, creates an impression that x is clearly a person because more or less misleading roundings and simplifications have to be performed at every stage and thus this method obviously seems implausible.

Table 1 presents a few more examples based on the foregoing weights and operations:

	Inputs			Outputs (fuzzy/conventional)
	Consist.	Politeness	Extroversy	Personality
Case 1	1	1	1	1 / 1
Case 2	0.5	0.5	0.5	0.5 / 1
Case 3	0.5	0.49	0.5	0.5 / 0
Case 4	0	0	0	0 / 0

Table 1. Examples of Degrees of Membership in The Context of Personality

First, Table 1 shows that conventional and fuzzifed operations yield identical outputs in cases 1 and 4, these being the clear (and precise) examples of a person and a non-person, respectively. Hence, this result is in accordance with the general idea of fuzzification that bivalent cases may be subsumed under fuzzified systems. Second, cases 2 and 3 show one basic problem characteristic of the conventional methods, viz. that almost identical input values may yield greatly different output values. This problem stems from the employment of classes with sharp boundaries which, in turn, leads to artificial cutoffs and more or less misleading roundings when classifications are performed, and hence this deficiency may not be eliminated by refining the

BEST COPY AVAILABLE

conventional classification in the context of the foregoing meaning components. The fuzzification approach, on the other hand, yields almost identical outputs from almost identical inputs, a result which seems intelligible.

In order to obtain applicable decisions, the foregoing strategy presupposes the employment of an appropriate *aggregation operator* such as the weighted arithmetic mean. On a general level, the aggregation operator is a function of the type

$$f: E_1 \times W_1 \times ... \times E_L \times W_L \rightarrow [0,1]$$

in which E_i is the reference set of the meaning component i and W_i ($\subset[0,1]$) is the set of weights ($1 \leq i \leq L$). Several alternative operators exist in the literature (cf. [11]). In practice, both logical and empirical facts should be taken into consideration when the aggregation operators are specified. For example, the arithmetic and the geometric mean usually emphasize logical and empirical aspects, respectively.

The mere degrees of membership may be problematic because precise values similar to conventional assessments are used. For example, a problem arises whether the correct input value is 0.51 or 0.52. On some occasions, especially when these values are based on empirical facts, this problem may be eliminated, but on a general level difficulties characteristic of the conventional methods are encountered (cf. [4]).

As the application of the mere degrees of membership will raise problems, fuzzy systems comprising *linguistic values* have been constructed. This approach usually presupposes (cf. [11]) a plausible logico-psychological framework, appropriate linguistic models and syntactic rules, intelligible interpretations of linguistic constituents which are based on the Theory of Fuzzy Systems, and applicable computer hardware and software. In practice, the following constituents are essential in the linguistic approach: (i) Linguistic variables (e.g. "Personality", "Age" etc.). (ii) Linguistic values (e.g. *clearly a person*, *more or less old*). (iii) A reference set E (e.g. the set of real numbers). (iv) Syntactic rules for linguistic expressions (e.g. conjunction and disjunction). (v) Semantic rules for interpreting the linguistic expressions using fuzzy sets (e.g. the meaning of *old* is the function m_{OLD}: E->[0,1]). Due to the extensiveness of this subject-matter the detailed considerations will not be discussed here and only some basic ideas will be outlined below. For further details the reader is referred, for example, to [11].

Thus, in the case of the foregoing example the linguistic approach presupposes that: (i) We have terms such as "Personality" and "Rationality" as the linguistic variables. (ii) We have sets of linguistic values such as {*irrational*, *more or less irrational*, ... , *rational*} assigned to each variable. It is recommendable that the construction of these sets is based on psychological facts

(see e.g. [11]) and appropriate syntactic rules in order to attain a correspondence with both natural language and the facts of the actual world. (iii) In this context the reference set E is usually the set of possible persons. (iv) The single numeric values of weights and degrees of membership are in this context replaced by fuzzy sets characterizing the linguistic values such as *rather important, very rational, fairly decent, having a rather good sense of humour* and *fairly inconsistent*. Hence, person x may be *very rational, fairly inconsistent* etc. The output sets (m_{OUTPUT}) characterizing the respective linguistic assessments, such as "x is a *rather typical person*", are obtained on the basis of the input sets (e.g. $m_{MORE\ OR\ LESS\ RATIONAL}$) applying the *extension principle* which includes aggregation operator f as the inducing mapping (cf. [15]), i.e., the ultimate fuzzy set m_{OUTPUT} is of the type

$$m_{OUTPUT}(z)=\max(\min(\ m_{INPUT1}(x),\ \ldots\ ,m_{INPUT2L}(x)\ )$$
$$z=f(x_1,\ldots,x_{2L})$$
$$x_i \in E_i\ (i=1,\ \ldots\ ,2L)$$
$$z \in E$$

As the output sets are unlabelled, the *linguistic approximation* (cf. [15]) has to be performed in order to assign an appropriate linguistic value to the obtained set. This procedure is based on taxonomical methods.

When fuzzy linguistic models are used, problems related to both the mere degrees of membership and conventional methods are eliminated because linguistic values may be regarded as elastic restrictions, thus better describing the nature of vague concepts. On a practical level, however, certain problems will arise: For example, what is the correct membership function characterizing a given linguistic value? As was stated above, a plausible logico-psychological framework, *inter alia*, will considerably facilitate the examination on these subject-matters.

Although the foregoing specifications seem laborious in practice, these procedures may be carried out elegantly and conveniently using a computer and appropriate software. It is thus possible to some extent, at least, to automate the concept formation of "personality". The future developments in artificial intelligence and neural networks, such as automated problem-solving, object-oriented programming, learning automata, parallel processing, associative reasoning, and fuzzy computers and programming languages, seem to open still better prospects for the computerized description of vague, complex and complicated expressions in the Behavioural Sciences.

In the light of the problems considered in Section 1 the following advantages are thus gained when the TFS is utilized in the description of terms in the Behavioural Sciences:

(i) Vague terms may be interpreted intelligibly. Hence, if conventional bivalent descriptions of terms, such as the real definition or the explication, seem to be impossible or inappropriate, vague descriptions may be used. The correct employment of the TFS guarantees that the borderline cases will be properly taken into consideration. In addition, both the psychological and the methodological requirements established for definitions in Section 1 may be satisfied.

(ii) In the context of complex terms the meaning components may overlap. Hence, differing from the case of the principle of family resemblance and the respective conventional methods, partial memberships of objects and meaning components may be specified meaningfully.

(iii) If the TFS is utilized correctly, the description of vague, complex and complicated expressions may be computerized conveniently, this clearly facilitating concept formation in the Behavioural Sciences.

(iv) In addition to concept formation, the TFS may be applied to various procedures in the conduct of inquiry. Examples of these are theory formation, model constructing and simulation.

3. Summary

The foregoing considerations may be summarized as follows: (i) The definition of "personality" is problematic using conventional methods because it is vague, complex and complicated by nature. (ii) The Theory of Fuzzy Systems, on the other hand, seems to be an intelligible approach because it deals with vague and complex entities elegantly. (iii) Owing to the employment of the TFS, computerized procedures may also be utilized conveniently in the concept formation of "personality". (iv) A concrete example of concept formation has been provided.

NOTES

1. Strictly speaking, the term "personality" does not directly refer to the set of persons, but by the virtue of it predicates, such as "being a person", may be formulated. Hence, the set of persons is actually the extension of the term "being a person". However, for the sake of simplicity it is assumed below that "personality" refers to the set of persons.

2. The symbol "$=_{df}$" means that the term to be defined (viz. the *definiendum*; on the left) has the same meaning as the defining expression, i.e., the *definiens*.

3. Analytic expression is true by the virtue of its logical form and/or by the meaning of its constituent terms. For example, "All bachelors are unmarried" is an analytic truth.

REFERENCES

[1] Bezdek, J. (Ed.): Proceedings of the 3rd IFSA Congress. Seattle, 1989.

[2] Carnap, R: The Logical Foundations of Probability. The University of Chicago Press, Chicago, 1950.

[3] Cohen, M. & Nagel, E: An Introduction to Logic and Scientific Method. Routledge & Kegan Paul, London, 1966.

[4] Haack, S: Is Truth Flat or Bumpy? In Mellor, D: (Ed.) Prospects for Pragmatism. Cambridge University Press, Cambridge, 1980.

[5] Hempel, C: Philosophy of Natural Science. Prentice Hall, New Jersey, 1966.

[6] Klir, G. & Folger, T: Fuzzy Sets, Uncertainty and Information. Prentice Hall, New Jersey, 1988.

[7] Maydole, R: Paradoxes and Many-Valued Set Theory. J. of Philosophical Logic 4, 1975.

[8] Nagel, E: The Structure of Science. Routledge & Kegan Paul, London 1961.

[9] Niiniluoto, I: Truthlikeness. Synthese Library, vol. 185. Reidel, 1987.

[10] Niskanen, E: Personality as an Educational Phenomenon. Research Bulletins 75, University of Helsinki, Department of Education, 1990.

[11] Niskanen, V: A Fuzzy System with Linguistic Values: Some Logical and Methodological Considerations and Applications. Research Reports 16, University of Helsinki, Computing Centre, 1986.

[12] Putnam, H: Philosophical Papers. Vol. 2, Cambridge, 1975.

[13] Wittgenstein, L: Philosophical Investigations. Vol. 1, McMillan, New York, 1953.

[14] Zadeh, L: A Fuzzy-Algorithmic Approach to the Definition of Complex or Imprecise Concepts. In Bossel, H. & al: (Eds.) Systems Theory in the Social Sciences. Birkhäuser Verlag, Basel, 1976.

[15] Zadeh, L: PRUF - A Meaning Presentation Language for Natural Languages. Int. Journal of Man-Machine Studies 10, 1978.

No. 52 The Ability to Structure Acoustic Material as a Measure of Musical Aptitude. 5. Summary and Conclusions by KAI KARMA. March, 1980. 33 pp.

xNo. 53 The Electronic Hand Calculator in Finnish Comprehensive School Mathematics Teaching by JOHANNES PAASONEN. Oct., 1980. 50 pp.

xNo. 54 Learning Process in Terms of Styles and Strategies: Theoretical Background and Pilot Study by ANNA-LIISA LEINO. Dec., 1980. 40 pp.

xNo. 55 Emotion and Cognition in Visual Art Education by INKERI SAVA. March, 1981. 46 pp.

No. 56 Classroom Analysis: Concepts, Findings, Applications. DPA Helsinki Investigations III edited by ERKKI KOMULAINEN and PERTTI KANSANEN. May 1981. 52 pp.

xNo. 57 Psychometric Test Theory and Cognitive Processes: A Theoretical Scrutiny and Empirical Research by JARKKO LEINO. October 1981, 74 pp.

No. 58 On the Dynamics of Undergraduate Performance and Dropout by KAJ MALM. April, 1982. 14 pp.

xNo. 59 Learning Process in Terms of Styles and Strategies: Case Studies by ANNA-LIISA LEINO. May, 1982. 51 pp.

No. 60 Research Project on Educational Aims by ERKKI A. NISKANEN & al. June, 1982. 105 pp.

No. 61 Admission to Teacher Education and Two Cognitive Styles by ANNA-LIISA LEINO — ARJA PUURULA. June, 1983. 54 pp.

No. 62 The Helsinki Test. The Inkblots and Using the Test by KARL BRUHN. October, 1984. 49 pp.

No. 63 Realization of Didactic Principles in Foreign Language Teaching in Soviet Schools by LYYLI RONKONEN. November, 1984. 30 pp.

No. 64 An Exploration of the Interpersonal Relationships, Health-Related Behavior and Physical and Mental Health of Finnish University Students by Vello Sermat. October, 1986. 29 pp.

No. 65 The Meaning of Life among Secondary School Pupils. A Theoretical Framework and Some Initial Results by HANNELE NIEMI. January, 1987. 81 pp.

No. 66 Some Principal Results of the Studies Carried out in the Research Project on Instructional Material by VESA A NISKANEN. October, 1987. 27 pp.

No. 67 Assessing Foreign Language Training Needs of Adults. A case study from Finland by KAARINA YLI-RENKO. April, 1988. 90 pp.

No. 68 Knowledge in Interactive Practice Disciplines. An analysis of knowledge in education and health care by ANNELI SARVIMÄKI. October, 1988. 276 pp.

xNo. 69 Intercultural Communication as an Aim of English Language Teaching by KAARINA YLI-RENKO. December, 1988. 45 pp.

No. 70 Integrating Information in Conceptual Models. Use of an information structure in building conceptual models for behavioural studies by SEPPO KONTIAINEN. January 1989. 59 pp.

No. 71 Theoretical Background and Development of Instructional Materials by JARKKO LEINO. April 1989. 25 pp.

No. 72 A Study of Learning Styles by ANNA-LIISA LEINO, JARKKO LEINO and JUHA P. LINDSTEDT. August 1989. 68 pp.

No. 73 Nonverbal Intelligence and Foreign Language Learning by IRENE KRISTIANSEN. May 1990. 164 pp.

No. 74 Pluralism and Education in Values by TAPIO PUOLIMATKA. October 1990. 31 pp.

No. 75 Personality as an Educational Phenomenon by ERKKI A. NISKANEN. October 1990. 44 pp.

No. 76 Describing Personality Utilizing the Theory of Fuzzy Systems by VESA A NISKANEN. October 1990. 16 pp.

x) Out of print.